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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.
B. T. GALLOWAY, Chief.

SPOT DISEASE OF THE VIOLET.

(*Alternaria violæ* n. sp.)

BY

P. H. DORSETT,
Associate, Division of Vegetable Physiology and Pathology.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Vegetable Physiology and Pathology,
Washington, D. C., August 29, 1900.

Sir: I respectfully transmit herewith a paper by Mr. P. H. Dorsett, of this Division, giving the results of some investigations of a disease affecting cultivated violets and generally known as spot. There is not less than a million dollars' worth of violet flowers sold every year in the United States, and were it not for the disease in question the amount would doubtless be increased 20 per cent. The annual loss from the disease, therefore, represents probably a money value of fully $200,000. In view of the general interest in violet culture and the importance of the knowledge of a means of preventing the disease, I respectfully recommend the publication of the paper as Bulletin No. 23 of this Division.

Respectfully,

B. T. Galloway,
Chief of Division.

Hon. James Wilson,
Secretary of Agriculture.

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SPOT DISEASE OF THE VIOLET.

INTRODUCTION.

The subject of this paper is one of the most widespread and destructive maladies known to attack the violet. The disease has been discussed in the florists' journals under a variety of names, such as leaf spot, leaf rust, leaf blight, smallpox, etc. More commonly, however, the trouble is known as the "violet disease," growers not generally recognizing the fact that there is more than one malady attacking the violet. The disease occurs throughout this country wherever the violet is grown, and is probably of American origin. The cultivation of the violet has been abandoned in many sections of the country on account of its ravages, while in others it has become necessary to adopt new methods of handling the plants during the growing season.

Five or six years ago, for example, 50,000 to 75,000 square feet of glass in the vicinity of Alexandria, Va., were devoted to the cultivation of this crop, but on account of the disease the industry has been practically abandoned. A large grower near Boston, Mass., was forced, a few years ago, to abandon growing stock plants at his place on account of this trouble. He had to have them grown for him during the summer, at considerable expense, in localities that were free or comparatively free from the disease. After transferring these plants to his place in the fall and setting them in the houses he experienced little or no difficulty in keeping them healthy during the remainder of the season. Many other instances of the destructive nature of this disease could be cited.

The large amount of florists' literature relating to this subject when collected and condensed was found by the writer to contain only a confused mass of contradictory opinions regarding both the cause and treatment of the disease. This is not strange to one familiar with the violet. All growers know the violet to be variable, seldom if ever behaving any two seasons alike. Practical growers recognize the fact that methods of handling the plants followed with little disease and good results during one season may, though rigidly adhered to, result in disease and failure the next. It is also a well-known fact that grow-

ers in the same section and in close proximity to one another often practice widely different methods in growing this crop, and yet the results obtained are practically the same. A novice in violet growing may have little or no difficulty the first few years in growing good flowers. After this, however, his troubles usually begin and failure more often than success crowns his efforts. Unless he is possessed of peculiar abilities and a determination to succeed a few years of reverses are sufficient to cause him to abandon the culture of violets and turn his attention to some other industry where the chances of success are at least equal to those of failure.

GENERAL APPEARANCE OF THE DISEASE.

Spot disease of the violet (*Alternaria violæ*) attacks the plants at any stage of their growth from the small unrooted cutting in the cutting bed to the mature plant in full flower. (See Pls. II, III, and IV.) Plants that are making a vigorous, rapid, but soft or succulent growth are most subject to the disease. The disease may occur on any portion of the plant above ground, but causes the greatest amount of loss when present upon the foliage. Its first appearance upon the leaves is characterized by small, definite, usually circular, greenish or yellowish white spots, resembling very much the bite or sting of an insect. They vary in size from dots scarcely perceptible to the unaided eye to spots a thirty-second of an inch or more in diameter. The light-colored central portion or point of infection is surrounded by a narrow ring of discolored tissue, usually black or very dark brown at first, but changing to a lighter shade as the spots grow older. (Pls. II, III, IV.) As the spot develops the central portion remains unchanged in appearance, while the tissues immediately surrounding it, either to one side or more frequently in a circle, become diseased by the ramifying growth of the mycelium of the fungus through this portion of the leaf. This usually takes place within a few hours after infection. The freshly diseased portion of the leaf at first presents a water-logged appearance, frequently being semi-transparent, and is lighter in color than the adjacent healthy tissue. The diseased portion around the central point of infection in a few days fades or bleaches to a yellowish or grayish white, sometimes to a pure white, the time depending somewhat upon the conditions of the weather. The development of the disease may stop at this point and the plants apparently entirely recover from its effects; in which event the diseased portions of the leaves after a few days separate from the healthy tissue and fall out, leaving the leaves full of holes. More frequently, however, the disease continues to develop in the parts of the leaf adjoining or surrounding those already diseased. These freshly diseased areas in turn pass through the same changes as the parts previously attacked. Unless checked by some means the disease continues to spread in this

way until the entire leaf is destroyed. It is seldom, however, that a single spot upon a leaf develops to this extent. More frequently the leaf is attacked at a number of different points (Pls. I, II, III, IV), and as the disease progresses the spots become larger and one or more of them coalesce, forming large irregular areas or blotches upon the leaf. (Pls. I, II.) A well-developed spot of this disease therefore shows a light-colored central portion, the point of infection, partly or wholly surrounded by alternate rings of dark and light colored tissue, the lighter colored portions as a rule being very much broader and more conspicuous than the darker. (Pls. I, II.) The majority of these spots are usually free from fungous spores except under conditions peculiarly favorable to their development. Spores are produced, however, in great abundance upon most of them, especially upon the central or older portions of the spots, after the leaves have been placed in a saturated atmosphere for from twenty-four to forty-eight hours. It is frequently the case that spores are produced in sufficient numbers to be discernible by the unaided eye, but usually the aid of a hand lens or a microscope is necessary to determine their presence. The spores are borne in chains on dark brownish hyphæ that rise from the diseased surface. Pl. V, fig. 2, shows a photomicrograph of some of the mycelium and spores of this fungus taken from a diseased spot in a living leaf. The spores break from their attachment and separate from each other easily, and being very small and light they are carried around by currents of air and finally settle upon other leaves.

THEORIES AS TO THE CAUSE AND TREATMENT OF THE DISEASE.

Perhaps no subject relating to floriculture has received more attention in the floricultural and horticultural journals during the past eight or ten years than the disease in question. The most varied opinions have been expressed in regard to it, and the explanations advanced as to its cause and the possible course of treatment are numerous. Some of the more important of these hypotheses are given here.

WEAKNESS OF THE PLANTS.

Some writers claim that the plants are of necessity weakened by being forced during the winter into heavy flower production, and that the taking of cuttings from such plants, and the rooting and forcing of them in the same way from year to year has resulted in producing a weak strain peculiarly susceptible to injury of all kinds. They recommend fall propagation to secure strong, vigorous, healthy wood before the plants are weakened by flowering. The cuttings, after being rooted in clean, sharp sand, are transplanted into thumb-pots or into flats and carried through the winter in a house or in frames, where the temperature is kept as low as possible, not allowing the

plants to freeze, however. By this treatment the plants are given a rest, which is believed by many to be necessary to strong, vigorous growth. While growers generally admit that slightly better results are usually obtained by this treatment than by the one generally practiced, they are, as a rule, of the opinion that the benefits derived will not justify the expense necessary to carry the young plants through the winter in good condition for spring planting. This is an important problem, the practical solution of which would no doubt prove of great value to all interested in the cultivation of the violet. We have this work under way at the present time, and hope in a few years to obtain some interesting results.

IMPROPER SOIL CONDITIONS.

Other writers claim that the disease is due to improper soil conditions. The soil is either too heavy or too light in texture, and as a consequence holds, or gives up, too much or too little moisture, or contains too much or too little plant food. They advise selecting soil suited in every way to the best growth and development of the plants.

Since good soil is one of the prime factors governing strong, vigorous, healthy plant growth, their advice is good, but extremely difficult to follow. The question of securing proper soil is one of the most perplexing with which the grower has to contend, requiring judgment that can be gained only by many years of practical experience.

IMPROPER CONDITIONS FURNISHED THE PLANTS DURING THE GROWING AND FLOWERING SEASON.

Still others attribute the disease to improper methods employed during the growth of the plants, such as growing them in the open field, where they are exposed to drought, rains, dews, and the direct rays of the sun during the summer, and lack of attention to properly heating, ventilating, and fumigating the houses and to cultivating, watering, and cleaning the plants. As a remedy they propose furnishing the necessary conditions for vigorous, healthy plant growth at all times. This is a good doctrine, but begs the question.

FUNGOUS NATURE OF THE DISEASE.

Over four years ago the writer succeeded in producing upon violet leaves spots that were in every way identical with those above described by spraying the leaves with distilled water to which spores of the fungus *Alternaria violæ* had been added. Since that time he has proved by numerous laboratory and greenhouse experiments (details of which will appear in the following pages) that the so-called "spot disease" of the violet is unquestionably due to the attacks of this fungus. Other fungi, *Cercospora violæ* Sacc., *Phyllosticta violæ* Desm., *Septoria violæ* Westd., etc., are known to attack the violet, producing upon the

leaves spots very similar in outline and appearance to those caused by *Alternaria violæ* (with which they are often confused), but in the writer's experience in the study of the violet and its diseases he does not recall a single instance where these fungi have come to his attention as causing any serious trouble. It is possible, however, for them to do considerable damage under conditions peculiarly favorable to their development.

Ninety-five per cent of all the specimens of the so-called violet disease received at the Division laboratory during the past four or five years were found, upon careful microscopical examination, to contain spores of the particular fungus mentioned.[1]

The fungus was isolated by agar poured cultures in Petri dishes, and comparatively little difficulty was experienced in securing pure cultures for inoculation experiments. The growth and development of the fungus on artificial media is, as a rule, quite rapid, normally producing spores in from four to six days after the sowing of the spores or the transferring of a single germinating spore from one plate culture to another.

The growth of the fungus in agar is normally in concentric rings, each ring marking the amount of growth made in twenty-four hours (Pl. V, fig. 1). The color of the fungus growing on agar before spore formation is grayish white (Pl. V, fig. 3). Spore production begins at the center on the older growth, and gradually extends outward, until the entire surface of the colony is covered with a dense mass of olivaceous spores. The fungus grows well on other culture media, especially young lima bean pods (Pl. VI, fig. 18).

The first inoculation experiment with *Alternaria violæ* was made February 12, 1896. Two plants of Marie Louise violet, in 4-inch pots, were removed from the Department greenhouse to the laboratory. They were quite uniform in size and, as far as could be ascertained by observation, entirely free from disease. Plant No. 1 was sprayed with sterile distilled water and placed under a bell jar in a sat-

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[1] SCIENTIFIC DESCRIPTION OF THE FUNGUS.

Alternaria violæ Galloway and Dorsett.

Amphigenous, but especially epiphyllous, olivaceous, velutinous, on light-colored subcircular definitely limited spots 2–4 mm. in diameter, extending into arid patches 10–12 mm. in diameter, which show one or more dark concentric lines; spore-bearing hyphæ fasciculate, erect, pale olivaceous, septate, simple, 4 by 25–30 μ; conidia borne at or near tips of the hyphæ, catenulate, clavately flask-shaped, muriform, strongly constricted at the septa, which are variable in number, olivaceous, 10–17 by 40–60 μ exclusive of isthmus, which is 3–5 by 3–25 μ.

Dr. Gino Pollacci has described and figured (Atti del R. Inst. Bot. dell'Univ. di Pavia (Laboratorio crittogamico) Ser. II, Vol. V, pp. 1–2, Pl. VII, figs. 1–5, 1897) a spot disease of violet occurring in Italy which is due to a fungus which he names *Macrosporium violæ*. If his description and drawings are correct the two diseases are quite distinct.

urated atmosphere, where it was kept. Plant No. 2 was sprayed with sterile distilled water in which spores from a pure culture of *Alternaria violæ* had been sown, and was then placed under the same conditions as plant No. 1. The temperature of the laboratory at the beginning of the experiment—3.30 p. m.—was about 80° F. The following notes, made during the progress of the experiment, are descriptive of the results obtained:

February 14, 1896, 9.30 a. m. Plant 1 apparently in a perfectly healthy condition, leaves covered with moisture, but showing no ill effects from the spraying or from being kept in a saturated atmosphere. Plant 2 badly diseased, nearly every leaf showing one or more spots of infection, which are in every particular identical with the first stages of the disease as naturally produced.

February 15, 1896, 9.30 a. m. Plant 1 still remains healthy and apparently uninjured by the treatment. On plant 2 the disease is progressing rapidly. There is a peculiarly disagreeable odor present when the bell jar is removed that is not noticeable under the same conditions with plant 1. This odor, so far as I am able to judge, is identical with that noticed with plants suffering from an attack of the disease under normal conditions. This odor is one of the characteristics of the disease, and its presence in the house, frame, or field is usually the first intimation the grower has of the presence of the disease among his plants.

February 19, 1896. Plant 1 still healthy and apparently in good condition. The spots on plant 2 are a little further developed and resemble more closely those produced under natural conditions.

A striking example of the results obtained by artificial inoculations of violets with this fungus is shown in Pl. IV. The two plants shown in this photograph received the same treatment as that given the two plants in the experiment described. The plants were sprayed at 3.30 p. m., August 26, 1896, and examined first at 2.30 p. m., August 27, 1896, just twenty-three hours after treatment. At this time plant No. 1 appeared free from disease, and showed no ill effects whatever from the treatment. On the contrary each leaf of plant No. 2, with one or two exceptions, showed from 1 to 30 or more spots of the disease, which were in every way identical with those produced on plant No. 2 in the previous experiment.

The plants were photographed August 31, 1896. At this date plant No. 1 was apparently free from disease, while the disease on plant No. 2 had made considerable progress and the spots were gradually assuming the normal colorings which are characteristic of this disease.

In these spots thus produced a careful microscopic examination demonstrated the presence of the mycelium of the fungus, and subsequent observation showed that the fungus pushed through to the surface of the spots and fruited, whenever the leaf was put under a bell jar in moist air, exactly as it did on spots occurring naturally. The disease was again produced in healthy plants by inoculation with the spores thus formed.

That the spots produced upon violet leaves by artificial inoculations with spores of *Alternaria violæ* closely resemble those occurring natu-

rally can be readily determined by comparing Pl. III, which is a photograph of a naturally diseased and a healthy plant from greenhouses at Garrett Park, Md., December 18, 1897, with Pl. IV, which is a photograph of a healthy and an artificially infected plant. The similarity of the spots is, however, more strikingly shown in Pl. I. Fig. 1 is a healthy leaf; fig. 2 is a diseased leaf from a plant naturally infected with the disease, while leaves 3 and 4 were taken from the diseased plant shown in Pl. IV, which was artificially infected with the disease.

Spores of the fungus *Alternaria violæ* sown in water in a van Tieghem cell and kept at a temperature of 65° to 80° F. germinate readily in from one and a half to three hours. Fig. 9, Pl. VI, is a camera lucida drawing of a group of spores that were sown in distilled water and placed in a van Tieghem cell at 10 a. m., January 15, 1898. The dotted lines at right angles to several of the germ tubes mark the amount of growth made by them between the time of sowing and the time noted; all subsequent growth and the production of all germ tubes not marked with a dotted line occurred between 11.55 a. m. and 2.10 p. m. the same day. Figs. 1 to 6 show a camera lucida drawing of a group of *Alternaria* spores in distilled water just previous to being placed in a van Tieghem cell, and figs. 7 and 8, two spores in the same sowing, nineteen hours later. Figs. 11, 13, and 14 show spores that were sown in distilled water in a van Tieghem cell at 10.20 a. m., August 19, 1898, at which time they showed no signs of germinating. Four hours later, however, at 2.20 p. m., the time at which the drawings were made, the number of germ tubes had developed as indicated. Fig. 12 is a second drawing of fig. 11, made twenty minutes later. Fig. 10 is a camera lucida drawing of two spores from four to six hours after being placed in distilled water. Figs. 15, 16, and 17 show the chain formation of spores and their attachment to the mycelium. This drawing was made from a pure plate culture of the fungus.

Numerous greenhouse and laboratory experiments under strict control conditions have confirmed these results, and show that spot disease of the violet is due directly to the attack of the parasitic fungus *Alternaria violæ*, and not to any of the other causes suggested. Indirectly, however, other conditions may have their effect. Any one or a combination of all of the conditions included in the various theories advanced may cause the plants to become susceptible to the attacks of the fungus.

CONDITIONS FAVORING THE DEVELOPMENT AND SPREAD OF THE DISEASE.

The conditions favoring the development and spread of the fungus may be considered under two heads, viz, natural conditions and artificial conditions.

Among natural conditions those of the damp, warm, cloudy weather of the summer season are the most difficult to modify or control.

Conditions of this nature are almost invariably present during the months of August and September. The days are long and usually hot and dry, followed, as a rule, by cool, moist nights. The plants at this time are subjected to extreme changes, viz, from the hot, dry atmosphere during the day, which frequently causes them to become wilted and remain so for several hours, to the cool, moist atmosphere of the night, which causes them to become excessively turgid. Conditions of this kind induce a rapid, weak, soft, or succulent growth of the plants which is particularly subject to disease and at the same time favors the germination and development of the spores of the fungus. It is at this season of the year, as a rule, that the spot disease is most abundant and destructive. This is the time for great vigilance, and every condition influencing plant growth must be made as favorable as possible to a hardy, healthy growth which will be able to withstand the attacks of disease. The grower who is able to accomplish this and tide his plants over this critical period of their growth in a comparatively healthy condition is fortunate, and, as a rule, has little to fear from the disease during the remainder of the season.

Artificial conditions include those wholly or in part under the control of the grower. They are too often neglected, resulting as a rule in disease and consequent loss and discouragement. They may be enumerated as follows:

(1) Not keeping the houses or frames clean, fresh, and sweet by frequently repairing and painting them and by removing and destroying rubbish of all kinds as soon as it appears.

(2) Not keeping the plants clean and in the best possible growing condition at all times.

(3) Not selecting stock from strong, vigorous plants that have been entirely free from disease.

(4) Not being careful to select only strong, vigorous, healthy stock from the cutting bed for planting in the spring.

(5) Not giving the proper attention to the selection and preparation of the soil, to the date and method of planting, and to the care and cultivation of the plants during the growing season.

(6) Not giving due consideration to the several varieties and their adaptability to the soil and location in which they are to be grown.

SUSCEPTIBILITY OF VARIETIES.

While the susceptibility of the plant to disease depends largely upon the way in which it has been grown, still, as a whole, some varieties are more susceptible than others; Marie Louise, for example, even under conditions most favorable to growth, is more subject to injury from spot than is Lady Hume Campbell. The former variety can be grown to perfection only under the most favorable conditions, but when thus grown it has no equal for size, color, and excellency of flower. The hardier, more resistant, and more prolific variety Campbell stands

next to Marie Louise in quality of flowers, lacking only the deep rich color of the latter. The single varieties are as a rule more resistant than the double, though occasionally they are seriously affected. (Plate VII.)

PREVENTIVE MEASURES.

So far as we are aware there is at present no effective remedy for this disease when it has gained a foothold. The principal fungicides in common use for the prevention and check of plant diseases have frequently been tried for this trouble, but with varying results. The experiments of the Division in spraying violets with some of the more important of these, among them Bordeaux mixture and ammoniacal solution of copper carbonate, seem to show that they possess little or no value in preventing the disease, while on the other hand they render the foliage worthless for bunching with the flowers, and thus occasion considerable loss and inconvenience. From the writer's experience and that of many others it would seem that the solution of this problem of controlling the disease lies in preventing it by giving careful attention to the production of vigorous, healthy, plant growth rather than in attempting to check the trouble after it has once gained a foothold.

The successful growing of violets free from disease and the production of flowers of the best quality are governed by a number of factors which must be kept in mind. The principal rules which should govern the grower are the following:

(1) Study carefully the behavior of the plants under the varying conditions surrounding them. Endeavor by modifying these conditions, when necessary, to secure plants of ideal development. Set the standard of excellence high and be satisfied with nothing short of its attainment.

(2) Grow the plants during the entire season where they can be given the conditions necessary for making a vigorous, healthy growth, and where they can be protected at all times from conditions likely to induce disease.

(3) Keep the houses or frames clean, sweet, and in perfect condition for growing healthy plants, by repairing and painting them when necessary, and by removing and destroying all rubbish likely to harbor vermin or disease.

(4) Propagate only from healthy, vigorous stock of known parentage at the season most favorable to the plants.

(5) Select each spring none but perfectly healthy, vigorous plants from the rooted cuttings for planting into the houses or frames. Old plants are sometimes carried over, and occasionally yield a large crop of flowers. They are not as reliable as the young plants, however, and are much more liable to all kinds of disease. The best growers rarely use them if it is possible to secure strong, healthy young plants for spring or early summer planting.

(6) Keep the plants clean of yellow, dead, or dying leaves, being careful to destroy them after removing them from the plants.

(7) Keep the plants free from insects and other animal pests.

(8) Give careful attention to ventilating, heating, and shading the houses or frames and to watering, cleaning, and cultivating the plants.

(9) Renew the soil in the beds each season before setting in the young plants by removing from eight to twelve inches of the surface soil and replacing it with that freshly prepared.

(10) Set the young plants early in the spring in the beds where they are to remain during the season, so that they may get well established before the hot, dry weather of summer makes its appearance.

Careful attention given to the above directions for a number of years will, it is believed, result in the production of a strain of plants that are not only practically disease resistant, but are also ideal as regards regularity and symmetry of growth, length, and strength of flower stems, and yield, size, substance, and quality of flowers produced.

EXPLANATION OF PLATES.

PLATE I. Healthy and diseased leaves of Marie Louise violet. (Natural size.) Fig. 1, healthy leaf. Fig. 2, naturally infected leaf. Figs. 3 and 4, artificially infected leaves from the diseased plant shown in Plate IV.

II. Young plants of Marie Louise violet from the cutting bed, showing spot on the leaves.

III. Fig. 1, healthy plant of Marie Louise violet for comparison. Fig. 2, diseased plant (natural infection).

IV. Fig. 1, healthy plant of Marie Louise violet (control). Fig. 2, diseased plant (artificial infection).

V. Fig. 1, growth of the fungus in eleven days from a single spore on an agar plate. Fig. 2, photomicrograph of mycelium and spores of *Alternaria violæ* from violet leaves. Fig. 3, pure plate culture of *Alternaria violæ*.

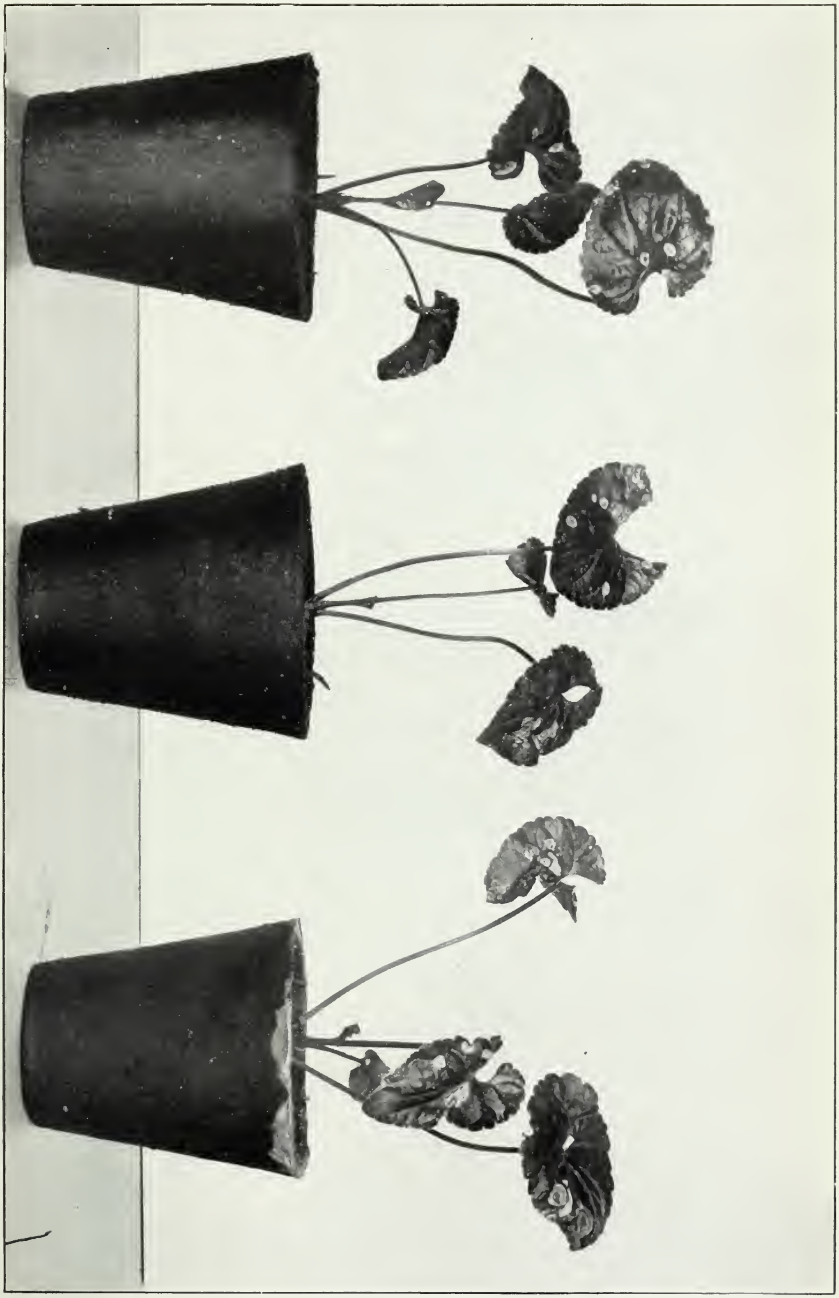
VI. Figs. 1 to 6, inclusive, show spores as they appear when brushed from a diseased spot. Figs. 7 and 8, some of the same spores after nineteen hours in distilled water in a van Tieghem cell. Fig. 9, a group of germinating spores. The length of the germ tubes at the time of the first examination is indicated by the dotted lines, and time marked; all subsequent growth of these tubes occurred, and all unmarked tubes developed, between the time marked and 2.10 p. m. Fig. 10, two connected spores germinating at several points after being about four hours in distilled water. Fig. 11, germinating spore. Fig. 12, the same spore twenty minutes later. Figs. 13 and 14, germinating spores. Figs. 15, 16, and 17, spores produced on agar, showing manner of attachment to mycelium and chain formation of spores. Fig. 18, pure culture of *Alternaria violæ* on sterilized lima bean. The darker part of the culture is thickly covered with spores; the white marginal portions are young growing mycelium.

VII. Fig. 1, healthy leaf of California violet. Figs. 2 and 3, diseased leaves of California violet.

O

D. G. PASSMORE.

HEALTHY AND DISEASED LEAVES OF MARIE LOUISE VIOLET.



YOUNG PLANTS OF MARIE LOUISE VIOLETS FROM THE CUTTING BED, SHOWING SPOT ON LEAVES.

A HEALTHY AND A NATURALLY INFECTED MARIE LOUISE PLANT.

A HEALTHY (CONTROL) AND AN ARTIFICIALLY INFECTED MARIE LOUISE PLANT.

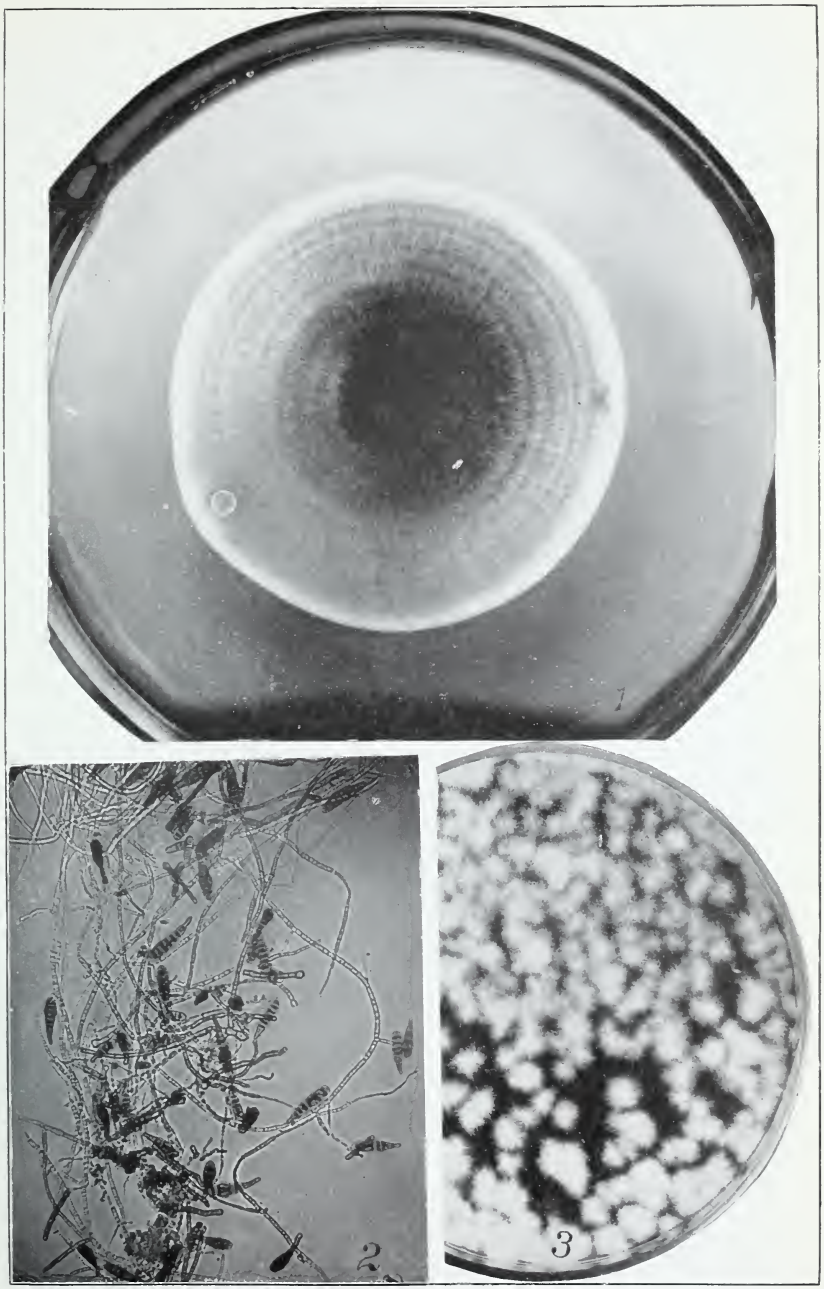
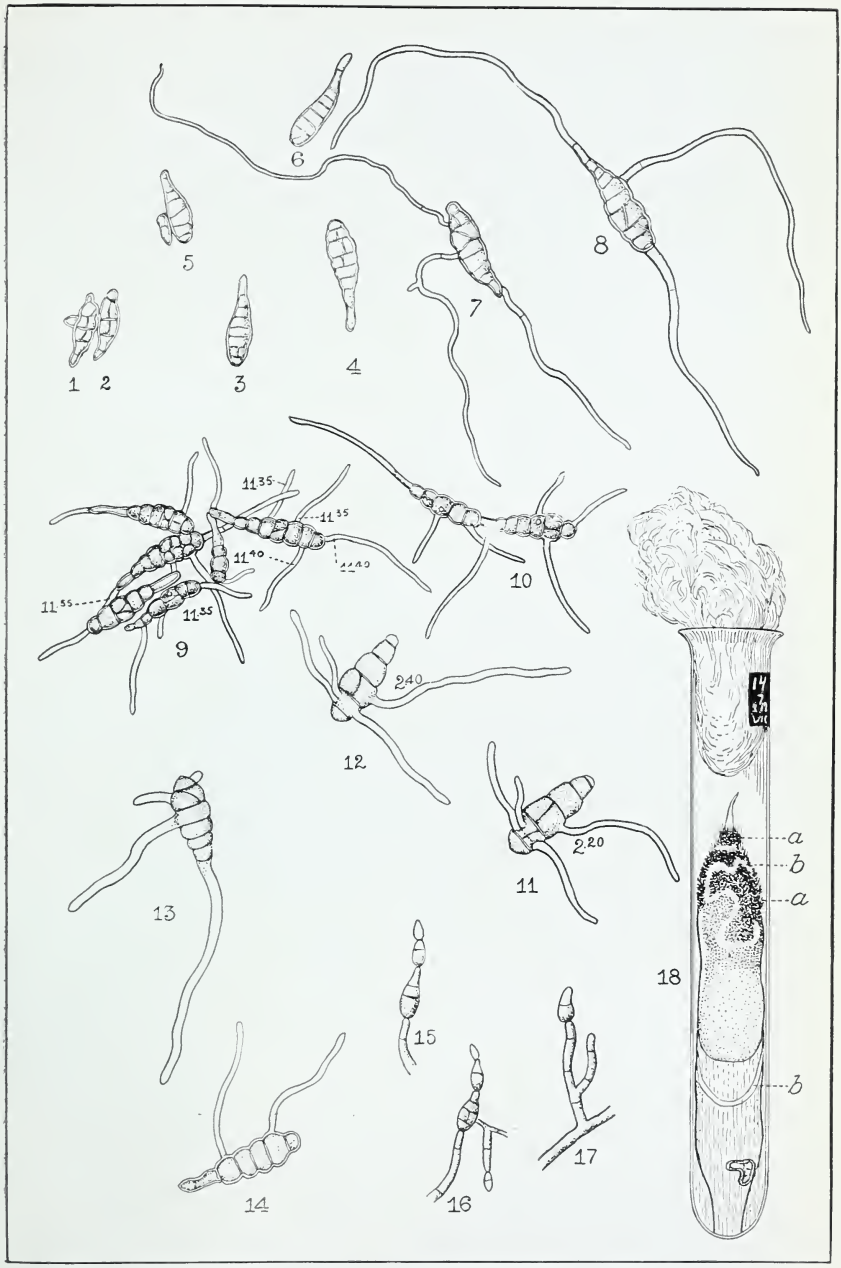


PLATE CULTURE OF ALTERNARIA VIOLÆ, AND MYCELIUM AND SPORES FROM A DISEASED LEAF.



DEVELOPMENT AND GERMINATION OF SPORES OF ALTERNARIA VIOLÆ AND PURE CULTURE UPON LIMA BEAN.

DISEASED AND HEALTHY LEAVES OF CALIFORNIA VIOLET.